Final Report

A project under the Canada
New Brunswick Conservation
and Renewable Energy
Demonstration Program

Enerplan consultants ltd.
energy planning and engineering

ENERGY EFFICIENT CHURCH 57

ST. MICHAEL'S CHURCH
MONCTON, NEW BRUNSWICK

February, 1985

C.R.E.D.A. PROJECT #2050

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Canada/New Brunswick Conservation and Renewable Energy Demonstration Program

The Conservation and Renewable Energy Demonstration Program Program is administered in New Brunswick by the Energy Secretariat and managed jointly with Energy, Mines and Resources Canada. The Program is designed to help demonstrate promising conservation and renewable energy technologies, to develop public awareness and understanding of these technologies, and to create employment in new or existing industries.

Through over 100 demonstration projects in New Brunswick, a wide variety of conservation and renewable energy technologies have proven to be technically sound and economically attractive. These demonstration projects should now provide a catalyst for commercialization and lead to widespread adoption of many of these proven technologies.

This final report is based on a project which was financially supported by the Energy Demonstration Program. For further information on other demonstration projects funded in New Brunswick under this program, contact:

Conservation & Renewable
Energy Division
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Programme Canada/Nouveau-Brunswick de démonstration des économies d'énergie et des énergies renouvelables

Le Programme de démonstration des économies d'énergie et des énergies renouvelables est administré au Nouveau-Brunswick par le Secrétariat à l'énergie, en collaboration avec Energie, Mines et Ressources Canada. Ce programme tente d'abord de vérifier la fiabilité des techniques de conservation d'énergie, d'accroître la sensibilité du public envers ces techniques et, enfin, de favoriser la création d'emplois au sein des industries nouvelles ou déjà existantes.

Un grand nombre de projets de démonstration se sont avérés à la fois techniquement réalisables et économiquement attrayants.

Le succès ainsi rencontré encourage la commercialisation des procédés les plus accessibles. Cela entraînerait certes l'adoption d'un grand nombre de ces techniques par les propriétaires de domiciles et par l'industrie privée.

Ce rapport final est basé sur un projet qui a reçu une aide financière du Programme de démonstration. Pour de plus amples renseignements, communiquez avec la:

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D E N I D E R E S P O N S A B I L I T E

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1.0 EXECUTIVE SUMMARY

1.0 Executive Summary

St. Michael's Church, a design based on the geodesic dome has proven to be very economical in terms of energy consumption. The building has been designed and built with energy efficiency in mind. The building envelope, heating and cooling systems, domestic hot water system and lighting systems have all been used to demonstrate energy conservation technology.

The geodesic dome has a lower exterior surface area to floor area ratio than a conventional box shape. The heat loss or gain potential of this building is therefore less, due to less transfer area compared to conventionally shaped churches. Useable floor area remains the same. The exterior is insulated to R-40 (RSI 7.2) with fibreglass batt and urethane foam. The slab is insulated to 4 feet from the wall perimeter with 2 inches of styrofoam.

Heating and cooling is done by air to air heat pumps with auxiliary electric heat for very cold weather.

Domestic hot water is provided by an instantaneous water heater.

Lights are high intensity metal halide indirect lighting for the main area and energy saving fluorescent lighting for entries.

Energy consumption in this all-electric facility was 7.6 kilowatt hours per square foot for the year from June, 1983 to May, 1984 inclusive.

1.0 Résumé

L'église St. Michael, basée sur le design du dôme géodésique, s'est avérée être très économique en ce qui a trait à la consommation énergétique. C'est avec cette dernière variable en tête qu'on a conceptualisé et construit ce bâtiment. Le squelette de l'édifice, les systèmes de chauffage et de refroidissement, les systèmes d'eau chaude sanitaire et d'éclairage ont servi à démontrer une technologie en économie d'énergie.

Comparativement au design carré conventionnel, le ratio de la surface extérieure, dans un dôme géodésique, est inférieur à la surface du plancher. Par conséquent, les pertes ou les gains de chaleur dans cet édifice sont réduits en raison de la surface de transfert qui est moins importante que celle qui est rencontrée dans les églises de structures conventionnelles. Toutefois, l'aire du plancher utilisable demeure la même. La valeur isolante à l'extérieur du bâtiment est de R-40 (RSI 7.2) avec l'utilisation de lattes de fibre de verre et de mousse d'uréthanne. On a isolé la dalle jusqu'à 4 pieds du périmètre du mur avec 2 pouces de styromousse.

Le chauffage et le refroidissement sont effectués à l'aide de pompes à chaleur air-air mais pour les gros froids, un système de chauffage électrique auxiliaire est utilisé.

L'eau chaude sanitaire est fournie par un appareil de chauffage d'eau instantané.

Dans les principaux endroits, on utilise une source lumineuse d'éclairage direct à halogène de grande puissance et dans les entrées, pour économiser l'énergie, des lumières fluorescentes.

La consommation énergétique de cette facilité toute à l'électricité est de 7.6 kilowatt-heures par pi2 à partir du mois de juin 1983 jusqu'en mai 1984 inclusivement.

2.0 INTRODUCTION

2.0 Introduction

St. Michael's Parish of Moncton, New Brunswick, planned to build a church in 1982-83. The planning for their church included proposals to implement several modern technologies that would provide a well built energy efficient building.

ENERPLAN CONSULTANTS LTD. prepared and submitted a proposal for an energy demonstration project on the St. Michael's Church in July, 1982 to the Energy Secretariat of New Brunswick. This was accepted for funding under the Conservation and Renewable Energy Development Agreement in December, 1982.

The proposed project involved construction of 'geodesic dome' style structure using 2 x 10 lumber for framing and insulation to a value of R40. Modern technology was also applied to heating and cooling, domestic hot water, and lighting systems. Technical details are outlined in the following pages.

Once construction was finished, monitoring was undertaken for the 1983-84 season to establish the building's energy consumption profile.

3.0 TECHNICAL DESCRIPTION

3.0 Technical Description

3.1 General

The energy consumption of a church is influenced by such aspects as:

1. Structure
2. Heating
3. Lighting
4. Domestic Hot Water

These items are the basis of this demonstration project and all conclusions and recommendations are based on them. Since this is a new building there was no previous monitoring done.

3.2 Structure

The St. Michaels Church is in the shape of a geodesic dome. The shape offers approximately the same amount of floor space as a conventional church, but with about 30% less exterior surface area. This provides for less area of heat exchange with the atmosphere and consequently an inherent energy saving.

The outside walls and roof are 2 x 10 framing with R32 batt insulation between the lumber. The inside surface is covered with a 6 mil polyethylene vapor barrier and a half inch of drywall/plaster finish. The outside surface has a 1 to 1½ inch coating of urethane. The concrete slab floor is insulated with 2 inches of styrofoam.

3.0 Technical Description (Cont'd)

3.2 Structure (Cont'd)

The windows and doors of the structure are thermally sealed. The main entrance has two sets of double doors and a vestibule to minimize large air changes directly through the entrance of the Church.

Overall the church is a very airtight structure and has above average insulation R values.

3.3 Heating and Cooling

St. Michaels Church is equipped with a heating and cooling system. Consisting of two split system heat pump air conditioners, each with a five ton capacity. Auxiliary electric duct heaters are installed for use during extremely cold weather. Supply air is distributed through ductwork located in the concrete slab. Return air goes through two grilles in the back of the church leading to each air conditioner.

3.4 Lighting

The lighting in the St. Michaels Church is indirect, high intensity, metal halide lights. These provide a more efficient lighting system than the regular fluorescent or incandescent lamps. The indirect light also provides a softer light and provides a more functional atmosphere. Refer to Appendix "C" for a comparison of different lighting systems.

3.0 Technical Description (Cont'd)

3.5 Domestic Hot Water

The domestic hot water is supplied by an instantaneous water heater. The unit is installed at the point of use and heats water only as needed. This eliminates heat loss in a storage tank and in the supply lines.

4.0 PERFORMANCE OF SYSTEMS

4.0 Performance of System

4.1 Monitoring

The Church was monitored by obtaining copies of the power bills as they came in for one full year after the completion of the Church.* The results were excellent and proved the project was very worthwhile. Refer to Appendix "A" for a chart of the kilowatt hours consumed by the St. Michaels Church. Note that total electrical consumption from June 1983 to May 1984 inclusive was 53,920 kilowatt hours which in terms of the area of 7085 square feet calculates to equal 7.6 kilowatt hours per square foot.

During the first year humidity was found to be a problem. This problem was overcome by increasing the ventilation at times when humidity got too high. The humidity level now seems to be well controlled.

*Although an elapsed time meter was installed for the heat pumps it was never checked by the Church staff. Therefore power company bills are the only data available (Appendix C).

4.0 Performance of System (Cont'd)

4.1 Monitoring (Cont'd)

There was some apprehension about whether the lighting system would be adequate and acceptable. In fact the light is adequate and very well accepted by the Congregation.

5.0 PROJECT COST ACCOUNTING

5.0 Project Cost Accounting

The cost breakdown of this project is as follows:

Construction	$282,488.21
Engineering and Management	$ 4,000.00
Monitoring Equipment	$ 2,000.00
Recording and Reporting	$ 2,100.00
Information Transfer	$ 2,100.00
Project Total	$292,668.21
CREDA	$ 70,000.00
St. Michaels Parish	$222,668.21
	$292,668.21

6.0 COST BENEFIT ANALYSIS

6.0 Cost Benefit Analysis

This building is a new design. The proposal to make this new construction an energy demonstration project was accepted on the following proposed energy consumption budget.

	Proposed	Actual
Heating/Cooling	8.8 Kwh/sq. ft.	**6.1 Kwh/sq. ft.**
Lights	1.5 Kwh/sq. ft.	**1.1 Kwh/sq. ft.**
Domestic Hot Water	0.5 Kwh/sq. ft.	**0.5 Kwh/sq. ft.**
Misc. Power	1.8 Kwh/sq. ft.	**0.2 Kwh/sq. ft.**
TOTALS =	12.6 Kwh/sq. ft.	**7.6 Kwh/sq. ft.**

The actual total energy consumption from June, 1983 to May, 1984 inclusive works out to be 7.6 kilowatt hours per square foot. This figure, which is considerably lower than expected, certainly shows that the objective of building a church with a low energy budget has been achieved.

A number of reasons can be given for the operating budget being lower than expected. The actual insulation value is higher than first proposed (R40 rather than R35). Operating hours are slightly less than expected. The project has motivated the users to manage their building in an energy conserving manner.

6.0 Cost Benefit Analysis (Cont'd)

The cost benefit analysis cannot be measured in concrete comparative numbers. However, it is felt that this project is a very good demonstration to a large congregation and to the general public of modern technology available for their use.

7.0 INFORMATION TRANSFER

7.0 Information Transfer

A project summary sheet (Appendix "B") was produced by the Energy Secretariat and distributed to interested individuals and organizations.

The construction phase of the project was closely monitored by members of the building committee and **ENERPLAN CONSULTANTS LTD.** A large number of interested citizens visited the site during the construction phase due to the uniqueness of the structure.

Tours of the building were conducted by **ENERPLAN CONSULTANTS LTD.** on a number of occasions in 1983 and 1984. A display highlighting the energy efficiency of St. Michael's Church was prepared and shown at a 'Municipal Energy Conference' in November, 1984 held in Fredericton, NB.

8.0 CONCLUSIONS AND RECOMMENDATIONS

8.0 Conclusions and Recommendations

The energy efficiency of the St. Michael's Church has proved to be exceptional. The modern technologies used in the building have proven to be viable in both meeting the objective of a low energy budget and in their acceptance by the congregation.

The problem of humidity buildup in a well insulated and sealed building is one that must be allowed for either by ventilation or dehumidification. This should always be considered in the design stages.

This energy demonstration project has performed better than expected in terms of the energy budget. The consultants, therefore, recommend the following:

1) The technologies used in this project should be encouraged for use in other buildings under design.
2) Government should continue to promote energy conservation by increasing motivation and awareness of modern technology in the general public.

APPENDIX "A"

ENERGY CONSUMPTION

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1982												11,920
1983		34,480	16,560	14,880*	3280	2800	2960	1760	1760	3680	4240	8960
1984	8240	4880	7440	4560	2640							

* CHURCH COMPLETED LATE APRIL.

ST. MICHAEL'S CHURCH

CONSUMPTION (KWH)

APPENDIX "B"

EFFICIENCY OF LIGHT SOURCE

APPENDIX B

EFFICIENCY OF LIGHT SOURCES

LIGHT SOURCE	LAMP WATTAGE	BALLAST WATTAGE	LUMENS	RATED LAMP LIFE	LUMENS/ WATT
Incandescent	300	-	6,000	1,000	20
	500	-	9,900	1,000	20
	1000	-	23,300	1,000	23
Flourescent	40 CW	8	3,150	20,000	65
	40 WW	8	3,200	20,000	66
	75 CW	15	6,300	12,000	70
Mercury	250	35	11,050	24,000	39
	400	50	20,880	24,000	46
Metal Halide	175	40	14,000	7,500	65
	400	50	34,000	15,000	76
High Pressure Sodium	100	16	9,500	20,000	82
	250	53	26,600	24,000	88
	400	75	50,000	24,000	105
Low Pressure Sodium	35	8	4,800	18,000	112
	90	18	13,500	18,000	125
	180	36	33,000	18,000	153